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ABSTRACT

The aim of this study was to develop and describe a wheelchair mobility performance test in wheelchair basketball and to assess its construct validity and reliability. To mimic mobility performance of wheelchair basketball matches in a standardised manner, a test was designed based on observation of wheelchair basketball matches and expert judgement.

Forty-six players performed the test to determine its validity and 23 players performed the test twice for reliability. Independent-samples *t*-tests were used to assess whether the times needed to complete the test were different for classifications, playing standards and sex. Intraclass correlation coefficients (ICC) were calculated to quantify reliability of performance times.

Males performed better than females ($P < 0.001$, effect size [ES] = −1.26) and international men performed better than national men ($P < 0.001$, ES = −1.62). Performance time of low (≤2.5) and high (≥3.0) classification players was borderline not significant with a moderate ES ($P = 0.06$, ES = 0.58). The reliability was excellent for overall performance time (ICC = 0.95).

These results show that the test can be used as a standardised mobility performance test to validly and reliably assess the capacity in mobility performance of elite wheelchair basketball athletes. Furthermore, the described methodology of development is recommended for use in other sports to develop sport-specific tests.

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Skill performance; wheelchairs; task performance and analysis; paralympic

Introduction

In wheelchair court sports, the player, the wheelchair and the environment determine performance. All the activities an athlete does (or can do) with a wheelchair, the wheelchair–athlete activities, can be defined as mobility performance. Key determinants of mobility performance are the abilities of the athlete to accelerate, sprint, brake and turn with the wheelchair (de Witte, Hoozemans, Berger, Veeger, & van der Woude, 2016; Mason, Porcellato, van der Woude, & Goosey-Tolfrey, 2010). The actual mobility performance in wheelchair court sports should be assessed during a match, preferably by systematic (video) observation combined with the use of (inertial) sensors (Bloxham, Bell, Bhambhani, & Steadward, 2001; de Witte et al., 2016; Rhodes, Mason, Perrat, Smith, & Goosey-Tolfrey, 2014; Van der Slikke, Berger, Bregman, & Veeger, 2015). These observations and measurements during wheelchair basketball result in, for example, findings that players move across the field with light or no arm strokes for 24% (standard deviation [SD] 7) of the time (Bloxham et al., 2001) and that national standard players drive relatively more forward, while international standard players perform more rotational movements during a match (de Witte et al., 2016). Assessing mobility performance is a fundamental requirement for trainers and coaches to, for example, develop training schemes, discuss and improve the athlete's level of performance, detect strength and weaknesses of mobility performance and develop optimal wheelchair configurations. The use of systematic observation and/or sensor technology during matches can thus provide useful information about mobility performance. However, systematic observation is very time-consuming, and results of both methods are influenced by the continuously changing environment when participating in a match of wheelchair basketball. Each match has unique circumstances depending on, for example, the opponent, injuries or team composition.

In order to repeatedly monitor athletes' mobility performance, athlete performance on a standardised field-based test is assigned to be informative and helpful (Goosey-Tolfrey & Leicht, 2013; Vanlandewijck, Daly, & Theisen, 1999). Currently, there is no generally accepted validated mobility performance test available for wheelchair court sports in general and for wheelchair basketball specifically. To assess and monitor mobility performance in a controllable setting, the mobility performance during a match must be simulated. A simulation or test that is based on field activities – i.e., the

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match – will result in meaningful information for coaches, players and (embedded) scientists. Field-based tests are generally acknowledged as a feasible way to get an indication of the performance standard of athletes (de Groot, Balvers, Kouwenhoven, & Janssen, 2012). Field-based tests exist for wheelchair court sports, but they assess mainly other aspects of performance, such as game performance (ball skills) and athlete performance (e.g., maximal heart rate or oxygen consumption) and only some parts of mobility performance (Barfield & Malone, 2012; Byrnes & Hedrick, 1994; de Groot et al., 2012; de Groot, Valent, Fickert, Pluim, & Houdijk, 2016; Gil et al., 2015; Granados et al., 2015; Yilla & Sherrill, 1998).

Extensive systematic observation and analyses of mobility performance during wheelchair basketball matches have recently been done for wheelchair basketball (de Witte et al., 2016; Van der Slikke et al., 2016). These data were used to develop a standardised and worldwide-accepted wheelchair mobility performance (WMP) test. Feasibility is a precondition in the development process, and the test should be easy to take without advanced equipment. To further ensure a high external validity, the test should be performed by wheelchair basketball players in their own sports wheelchair and on a regular wheelchair basketball court. Furthermore, the test should discriminate between different categories of athletes (e.g., sex and playing standard), which is known from the literature that they differ in mobility performance (de Witte et al., 2016; Gomez, Perez, Molik, Szyman, & Sampaio, 2014; Van der Slikke, Berger, Bregman, & Veeger, 2015; Van der Slikke et al., 2016; Vanlandewijck, Daly, Spaepen, Theisen, & Pétré, 1999). Besides valid results, the test should give reliable data to monitor the actual capacity in mobility performance of athletes.

In this context, the goals of the present study were (1) to describe the development of a field-based wheelchair test that assesses mobility performance capacity and which closely mimics the wheelchair mobility skills required in real wheelchair basketball matches, (2) to define the developed field-based test and (3) to assess the construct validity and test–retest reliability of the newly developed field-based WMP test for wheelchair basketball.

Methods

Test development

The development process had a stepwise character: (1) examine match mobility performance, (2) determine practical test requirements and (3) organise expert meetings to verify the test design.

To examine mobility performance in matches, coaches were interviewed to describe and define wheelchair–athlete activities during wheelchair basketball. The wheelchair activities were assessed by systematic observation of video footage of matches (de Witte et al., 2016). Four matches at national playing standard and five matches at international playing standard were recorded. In total, 56 male wheelchair basketball players were analysed during an entire match. Time–motion analysis was used for determining the frequency and duration of these athlete and wheelchair activities (de Witte et al., 2016). Based on the results, wheelchair basketball mobility performance was defined in various dominant game-related wheelchair activities (Table 1). In order to make a translation from match data to test design, the output was organised into three main categories: separate activities, combined activities and activities with ball possession. For each of these categories, the most common wheelchair–athlete activities and distances were determined with inertial sensors (Van der Slikke, Berger, Bregman, Lagerberg, & Veeger, 2016).

In addition, practical test requirements were formulated for the WMP test based on interviews with coaches and experts: (1) The WMP test should be easy to use without advanced equipment; (2) The WMP test should take place in a realistic environment common to wheelchair basketball, e.g., athletes performed the test in their own sports wheelchairs and on a regular wheelchair basketball court; and (3) Fatigue should not be a limiting factor for performance. The observed activities and the requirements were used to draft the first test setup.

An expert meeting with coaches, players and researchers was organised to discuss the first version of the WMP test to increase its content validity, after which “specific skills” were added as a fourth main group. The four main groups contained a total of 15 different wheelchair–athlete activities (Table 2). Based on these data, a final version of the WMP test was developed which is described in the results section. The development process took place between March 2014 and March 2015.

Construct validity and test–retest reliability

To evaluate the construct validity and reliability of the newly developed WMP test, experienced wheelchair basketball players were included in different field-based standardised experimental sessions.

Participants

For the validity study, 46 players – competing at different playing standards – were included, and for the reliability

Table 1. Overview of the relative duration (±SD) as a percentage of wheelchair–athlete activities based on video analysis of 56 male wheelchair basketball athletes playing at national and international playing standard (de Witte et al., 2016).

Wheelchair activities	Outcome video analysis relative duration % (±SD)	Relative duration during ball possession % (±SD)	Outcome inertial sensors
Standing still	19 (6)	26 (16)	–
Driving forward	45 (6)	42 (12)	Most common: 3 m Maximal: 12 m
Driving backward	2 (1)	1 (1)	–
Rotate	29 (8)	28 (12)	Most common: radius 1.5–2.5 m
Brake	3 (2)	2 (2)	–

The data are complemented with information from data of inertial sensors based on 29 wheelchair basketball players (Van der Slikke et al., 2016).

Table 2. Setup test protocol based on observed wheelchair–athlete activities and distances (for the total test protocol, see Supplementary material I).

Main group	Activity	Distance	Direction
Separate activities	Driving forward	12 m	–
	Rotation	Radius 1.9 m (total circumference of 12 m)	Clockwise/counterclockwise
	Rotation on the spot		Clockwise/counterclockwise
Combined activities	Driving forward with two stops	3, 3 and 6 m = 12 m	–
	Rotation with two stops	90° (3 m), 90° (3 m), 180° (6 m) = 12 m	Clockwise/counterclockwise
	Rotation on the spot with stop	90°, 90°	Clockwise/counterclockwise
	Combined activities		–
Specific skills	Tik-tak box		–
Activities with ball possession	Driving forward	12 m	–
	Rotation	Radius 1.9 m (total circumference of 12 m)	Clockwise/counterclockwise

study, 23 players – competing at a national playing standard (Dutch first division competition) – participated. In the validity group, a distinction was made between men and women competing at an international standard and players competing at a national standard, and a distinction was made between low classification (≤2.5 points) and high classification (≥3.0 points) players. The International Wheelchair Basketball Federation uses a classification system based on the players' functional potential to execute fundamental basketball movements (International Wheelchair Basketball Federation, 2014). All players are scaled from 1 (minimal functional potential) to 4.5 points (maximal functional potential) on an ordinal functional level scale. The characteristics (classification, basketball experience and age) of the validity and reliability study groups are shown in Table 3. Players were informed about the procedures before giving their written informed consent. This study was approved by the Ethical Committee of the Department of Human Movement Sciences, Vrije Universiteit Amsterdam, the Netherlands.

Procedure

Prior to all tests, procedures were explained, and the test protocol was demonstrated using a video shown to all participants. Players were asked to refrain from smoking and drinking caffeine or alcohol at least 2 h prior to the WMP test. Before performing the WMP test, players carried out a self-selected warm-up. All players performed the WMP test in their own sports wheelchairs, with their own configurations and tires were inflated to 7 bar.

Participants of the validity study performed the WMP test once on the same synthetic soft-top basketball court. Participants were measured while being involved in training sessions and in the Euro Cup 4 tournament (April 2015, the Netherlands).

Participants of the test–retest reliability study performed the same test twice. Participants were tested during their training sessions, on the basketball courts where the teams trained, on two separate days at the same time of the day, with 1 week in between (October/November 2015).

Data acquisition and analyses

The WMP test simulated the 15 most common wheelchair–athlete activities during wheelchair basketball (Table 2). All the standardised activities were carried out in succession, separated by standardised rest periods to avoid fatigue. Two high-definition video cameras (CASIO EX-FH100, 1280*720, 20–240 mm) were placed at the side of the test. Each camera was focused on one half of the basketball court with a small overlap between the videos. The outcome of the WMP test was time (s), which was manually recorded from video analysis (Kinovea 0.8.15, France). These analyses resulted in 16 performance time values, one for each of the 15 wheelchair–athlete activities (*time activity no. 1–15*) and the *overall performance time*, which is the sum of the performance times of the 15 separate activities.

Statistical analyses

All statistical analyses were performed using IBM SPSS statistics version 22 (IBM Corporation, Armonk, NY, USA). Descriptive statistics for the *time activities no. 1–15* and the *overall performance time* were presented as mean ± SD. The assumptions of normality were checked with the Shapiro–Wilk test, as well as z-values of the skewness and kurtosis. Also, histograms, boxplots and q-q plots of the data were visually inspected. The assumption of normality was not violated.

Construct validity

To determine the construct validity of the WMP test, three hypotheses were formulated and tested. Hypothesis (1): Players with a high classification (≥3.0 points) are expected to perform better than players with a low classification (≤2.5 points) (Van Der Slikke, Berger, Bregman, & Veeger, 2015; Vanlandewijck, Daly, & Theisen, 1999). Hypothesis (2): Players playing at an international standard are expected to perform better than players at a national standard (de Witte et al., 2016; Van Der Slikke et al., 2015). Hypothesis (3): Men are expected to perform better than women because of sex differences in upper body strength and trunk stability as key determinants of mobility performance (Gómez et al., 2014).

To assess potential differences in the 16 performance time outcomes between classification categories, playing standards and sex, independent samples t-tests were used. The means ± SDs were completed with mean differences, 95% confidence intervals of the difference and P-values. Differences with P-values <0.05 were considered statistically significant. In addition, Cohen's d effect sizes (ES) were calculated for main effects as outlined by Cohen (1992). The (absolute) magnitude of the ES was classified as large (≥0.80), moderate (0.50–0.79) or small (<0.50) (Cohen, 1988).

Test–retest reliability

Test–retest reliability of the 16 time performance outcomes was evaluated with intraclass correlation coefficients (ICC(3,1)),

Table 3. General characteristics of the participants included in the construct validity (n = 46) and test–retest reliability (n = 23) analyses for classification 1–4.5.

	Classification	n	Experience in years (±SD)	Age in years (±SD)	Mean (±SD) and range of wheel size (cm)	Mean (±SD) and range of elbow angle with hand on the top of the rim (°)	Mean (±SD) and range of wheel camber (°)	Men playing at international standard (n)	Women playing at international standard (n)	Men playing at national standard (n)
Validity study	1–1.5	8	7.2 (4.8)	28.3 (7.1)	62.0 (2.4) 58–64	100 (11) 86–122	17 (1) 16–19	3	3	2
	2–2.5	11	12.9 (6.9)	28.9 (9.3)	62.8 (2.6) 59–68	117 (18) 77–135	17 (1) 15–19	6	3	2
	3–3.5	8	9.1 (3.3)	26.7 (10.0)	64.4 (1.1) 64–67	128 (18) 100–162	18 (1) 17–21	5	3	–
	4–4.5	19	8.4 (5.2)	24.7 (8.3)	64.5 (2.0) 61–68	136 (18) 99–168	18 (1) 15–21	7	4	8
Reliability study	1–1.5	2	4.0 (0.7)	21.0 (4.2)	61.5 (3.5) 59–64	87 (1) 86–88	17 (1) 16–17	–	–	2
	2–2.5	1	9.0	21.0	61.0	110	17	–	–	1
	3–3.5	5	6.4 (1.9)	16.8 (5.1)	60.4 (2.9) 58–64	104 (24) 81–136	18 (2) 15–20	–	–	5
	4–4.5	15	6.5 (6.4)	22.8 (10.8)	63.4 (2.5) 56–67	129 (16) 99–151	18 (1) 15–20	–	–	15

standard error of measurement (SEM) and limits of agreement (LoA). ICC(3,1) is a two-way mixed single measure of absolute agreement (Shrout & Fleiss, 1979). ICC scores ≥0.70 are indicated as satisfactory, values ≥0.75 are considered as good and values ≥0.90 are categorised as excellent reliability (Atkinson & Nevill, 1998). The SEM for agreement was calculated with Equation (1).

$$\text{SEM agreement} = \sqrt{\text{Var}_\text{o} + \text{Var}_\text{residual}} \tag{1}$$

Variance components were obtained from variance component analyses, and two components were estimated, variance attributable to observers (Var_o) and residual error ($\text{Var}_\text{residual}$).

The Bland–Altman method was used to examine the differences between the WMP test and retest for the whole group, including the calculation of the mean difference between the test and retest, the SD of the difference, and the 95% LoA (Bland & Altman, 1986). The LoA95 was calculated with Equation (2).

$$\text{LoA95} = \text{mean difference} \pm 1.96 * \text{SD difference} \tag{2}$$

The differences for the overall performance times were visualised in a Bland–Altman plot, where the individual differences between the test and retest are plotted against the mean of the test and retest.

Results

Design of the WMP test

The final version of the WMP test for wheelchair basketball consisted of 15 activities with a standardised period of rest between the activities. The WMP test is divided into four main groups. Group (1): Separate activities containing a 12 m sprint, a rotation with a curve (circumference) of 12 m (clockwise/counterclockwise) and a turn on the spot (clockwise/counterclockwise); Group (2): Combined activities containing the same activities as group 1, combined with starts and stops in between; Group (3): Specific skills consisting of a tik-tak box, which means performance of short movements forward and backward alternated with collisions against a stationary object. Group (4): A 12 m sprint and rotation (clockwise/counterclockwise) with a curve (circumference) of 12 m performed with ball possession (dribble) (for the total WMP test protocol and the sequence of the activities, see Supplementary material I).

Construct validity and test–retest reliability

Time scores of the tik-tak box (activity no. 1) of the WMP test were not included in both the reliability and the construct validity study. The start and stop times of this activity were not clearly visible at the video analysis, and because of this, the data are not presented and included.

Construct validity

To determine the construct validity of the WMP test, three hypotheses were formulated and tested.

Hypothesis (1): Players with a high classification are expected to perform better than players with a low classification. The overall performance time was borderline non-significant between high and low classifications (P = 0.06, ES = 0.58), but the magnitude of the ES can be interpreted as moderate (Table 4). For time scores on the individual activities, the classification analyses showed significant differences for driving forward movements and turn on the spots, in which high-classification players performed the activities faster than low-classification players. Significant differences between high and low classifications were observed for the 12 m sprint (mean difference = 0.32 s; ES = 0.92) and for the 3-3-6 m sprint (mean

Table 4. Mean (±SD) performance times (s) for each activity and overall performance time (s) of the wheelchair mobility performance test for classification (classification ≤2.5 points and classification >2.5 points) complemented with the mean difference between the classification groups, 95% confidence intervals of the differences and Cohen's *d* effect sizes.

		Classification ≤2.5 points (n = 19)	Classification >2.5 points (n = 27)			95% confidence interval of the difference			
		Mean (±SD)	Mean (±SD)	Mean difference	Standard error difference	Lower	Upper	*P*-values	Effect size
Activity 2	180° turn on the spot (left)	0.93 (0.09)	0.84 (0.08)	0.09	0.02	0.04	0.14	0.00[a]	1.04
Activity 3	12 m sprint	5.12 (0.42)	4.80 (0.28)	0.32	0.10	0.11	0.53	0.00[a]	0.92
Activity 4	12 m rotation (right)	5.97 (0.41)	5.90 (0.40)	0.07	0.12	−0.17	0.31	0.57	0.17
Activity 5	12 m rotation (left)	5.95 (0.47)	5.89 (0.39)	0.06	0.13	−0.19	0.32	0.62	0.15
Activity 6	180° turn on the spot (right)	0.95 (0.13)	0.89 (0.12)	0.06	0.04	−0.01	0.14	0.10	0.50
Activity 7	3-3-6 m sprint	7.19 (0.77)	6.64 (0.61)	0.55	0.20	0.14	0.96	0.01[a]	0.81
Activity 8	3-3-6 m rotation (left)	7.66 (0.84)	7.33 (0.61)	0.33	0.21	−0.10	0.76	0.13	0.47
Activity 9	3-3-6 m rotation (right)	7.58 (0.80)	7.23 (0.61)	0.36	0.21	−0.06	0.78	0.09	0.51
Activity 10	90°–90° turn on the spot with stop (left)	1.54 (0.19)	1.38 (0.17)	0.16	0.05	0.05	0.27	0.01[a]	0.87
Activity 11	12 m dribble	6.03 (0.70)	5.80 (0.68)	0.24	0.21	−0.18	0.65	0.26	0.34
Activity 12	12 m rotation dribble (right)	7.38 (0.91)	7.17 (0.87)	0.22	0.26	−0.31	0.75	0.41	0.25
Activity 13	12 m rotation dribble (left)	7.42 (0.97)	7.27 (0.68)	0.15	0.24	−0.34	0.64	0.54	0.19
Activity 14	90°–90° turn on the spot with stop (right)	1.41 (0.17)	1.31 (0.15)	0.10	0.05	0.00	0.19	0.05[a]	0.61
Activity 15	Combination	13.95 (0.95)	13.42 (0.67)	0.53	0.24	0.04	1.02	0.03[a]	0.67
Overall performance time (sum activities 2–15)		79.25 (6.56)	75.95 (4.97)	3.30	1.72	−0.17	6.77	0.06	0.58

[a]Significant effect of classification (P < 0.05).

Table 5. Mean (±SD) performance times (s) for each activity and overall performance time (s) of the wheelchair mobility performance test for differences in playing standard (international men and national men) complemented with the mean difference between the (international) groups, 95% confidence intervals of the differences, and Cohen's *d* effect sizes.

		International men (*n* = 21)	National men (*n* = 12)			95% confidence interval of the difference			
		Mean (±SD)	Mean (±SD)	Mean difference	Standard error difference	Lower	Upper	*P*-values	Effect size
Activity 2	180° Turn on the spot (left)	0.87 (0.09)	0.89 (0.12)	−0.02	0.04	−0.10	0.05	0.54	−0.22
Activity 3	12 m sprint	4.76 (0.34)	5.08 (0.45)	−0.32	0.14	−0.60	−0.03	0.03[a]	−0.84
Activity 4	12 m rotation (right)	5.72 (0.42)	6.16 (0.37)	−0.43	0.15	−0.73	−0.14	0.01[a]	−1.08
Activity 5	12 m rotation (left)	5.67 (0.38)	6.17 (0.38)	−0.51	0.14	−0.79	−0.23	0.00[a]	−1.33
Activity 6	180° Turn on the spot (right)	0.90 (0.15)	0.95 (0.15)	−0.05	0.05	−0.16	0.06	0.38	−0.32
Activity 7	3–3-6 m sprint	6.57 (0.75)	7.17 (0.73)	−0.60	0.27	−1.15	−0.06	0.03[a]	−0.81
Activity 8	3–3-6 m rotation (left)	7.01 (0.71)	7.88 (0.52)	−0.86	0.24	−1.34	−0.38	0.00[a]	−1.32
Activity 9	3–3-6 m rotation (right)	6.91 (0.56)	7.89 (0.60)	−0.99	0.21	−1.41	−0.56	0.00[a]	−1.72
Activity 10	90°- 90° turn on the spot with stop (left)	1.41 (0.21)	1.55 (0.18)	−0.14	0.07	−0.29	0.01	0.06	−0.71
Activity 11	12 m dribble	5.66 (0.63)	6.25 (0.67)	−0.59	0.23	−1.07	−0.12	0.02[a]	−0.92
Activity 12	12 m rotation dribble (right)	6.77 (0.69)	7.91 (0.77)	−1.13	0.26	−1.67	−0.60	0.00[a]	−1.57
Activity 13	12 m rotation dribble (left)	6.88 (0.73)	7.99 (0.72)	−1.10	0.26	−1.64	−0.57	0.00[a]	−1.52
Activity 14	90°–90° turn on the spot with stop (right)	1.28 (0.15)	1.49 (0.17)	−0.21	0.06	−0.32	−0.09	0.00[a]	−1.34
Activity 15	Combination	13.15 (0.70)	14.17 (0.86)	−1.02	0.28	−1.59	−0.45	0.00[a]	−1.34
Overall performance time (sum activities 2–15)		73.44 (4.95)	81.55 (5.08)	−8.11	1.83	−11.84	−4.37	0.00[a]	−1.62

[a]Significant effect of playing standard ($P < 0.05$).

difference = 0.55 s; ES = 0.81). However, for nearly all activities related to rotation (7 out of 10), there was no difference between classification categories.

Hypothesis (2): Players playing at an international standard are expected to perform better than players at a national standard. The WMP test showed a significant difference for playing standard for the overall performance time ($P < 0.001$, ES = −1.62). International men performed the WMP test on average 8.11 s faster than the national men (Table 5). The WMP test showed a significant difference between international men and national men for 13 of the 15 outcomes and showed that international men were faster on all the activities (moderate/large ES: 0.81–1.72). The WMP test showed no differences for three of the four activities that measured turn on the spot (no. 2, 6 and 10) (moderate/small ES: 0.71–0.22).

Hypothesis (3): Men are expected to perform better than women, both competing at the same playing standard. There was a significant difference between men and women on the overall performance time ($P < 0.001$, ES = −1.26). International men performed the WMP test faster than international women (Table 6). In addition, the WMP test showed differences between international men and international women on all activities with the exception of the activities that measured turn on the spot and 12 m dribble. A striking detail is that international women performed the rotation on the spot activities almost as fast as the international men (small ES: 0.02–0.44).

Test–retest reliability

The test–retest reliability analyses results are summarised in Table 7. The ICC value for the overall performance time was

Table 6. Mean (±SD) performance times (s) for each activity and overall performance time (s) of the wheelchair mobility performance test for differences in sex (international men and international women) complemented with the mean difference between the sex groups, 95% confidence intervals of the differences, and Cohen's *d* effect sizes.

		International men (*n* = 21)	International women (*n* = 13)			95% confidence interval of the difference			
		Mean (±SD)	Mean (±SD)	Mean difference	Standard error difference	Lower	Upper	*P*-values	Effect size
Activity 2	180° turn on the spot (left)	0.87 (0.09)	0.89 (0.07)	−0.02	0.03	−0.08	0.04	0.58	−0.20
Activity 3	12 m sprint	4.76 (0.34)	5.04 (0.27)	−0.28	0.11	−0.50	−0.05	0.02[a]	−0.90
Activity 4	12 m rotation (right)	5.72 (0.42)	6.07 (0.21)	−0.35	0.12	−0.60	−0.09	0.01[a]	−0.98
Activity 5	12 m rotation (left)	5.67 (0.38)	6.07 (0.29)	−0.40	0.12	−0.65	−0.15	0.00[a]	−1.15
Activity 6	180° turn on the spot (right)	0.90 (0.15)	0.90 (0.07)	0.00	0.04	−0.09	0.09	0.95	0.02
Activity 7	3–3-6 m sprint	6.57 (0.75)	7.06 (0.52)	−0.49	0.24	−0.97	−0.01	0.05[a]	−0.73
Activity 8	3–3-6 m rotation (left)	7.01 (0.71)	7.83 (0.45)	−0.81	0.22	−1.27	−0.36	0.00[a]	−1.30
Activity 9	3–3-6 m rotation (right)	6.91 (0.56)	7.65 (0.56)	−0.74	0.20	−1.14	−0.34	0.00[a]	−1.33
Activity 10	90°–90° turn on the spot with stop (left)	1.41 (0.21)	1.40 (0.14)	0.01	0.07	−0.14	0.15	0.93	0.03
Activity 11	12 m dribble	5.66 (0.63)	5.95 (0.70)	−0.30	0.23	−0.77	0.17	0.21	−0.45
Activity 12	12 m rotation dribble (right)	6.77 (0.69)	7.44 (0.84)	−0.67	0.26	−1.20	−0.13	0.02[a]	−0.89
Activity 13	12 m rotation dribble (left)	6.88 (0.73)	7.47 (0.51)	−0.58	0.23	−1.06	−0.11	0.02[a]	−0.89
Activity 14	90°–90° turn on the spot with stop (right)	1.28 (0.15)	1.34 (0.10)	−0.06	0.05	−0.15	0.04	0.22	−0.44
Activity 15	Combination	13.15 (0.70)	13.88 (0.55)	−0.73	0.23	−1.20	−0.26	0.00[a]	−1.12
Overall performance time (sum activities 2–15)		73.44 (4.95)	79.21 (3.88)	−5.76	1.63	−9.08	−2.44	0.00[a]	−1.26

[a]Significant effect of sex ($P < 0.05$).

Table 7. Descriptive values of 23 national male wheelchair basketball players (mean (s) ±SD) and mean differences for the test–retest complemented with reliability statistics (s): ICC(3,1) absolute agreement, 95% confidence interval of the ICC agreement, SEM and 95% limits of agreement.

		Test 1	Test 2			95% confidence interval of the ICC agreement			
		Mean (±SD)	Mean (±SD)	Mean difference (±SD)	ICC agreement	Lower	Upper	SEM agreement	Limits of agreement
Test 2	180° turn on the spot (left)	0.90 (0.15)	0.90 (0.10)	0.00 (0.15)	0.25	−0.19	0.60	0.10	0.30
Test 3	12 m sprint	5.02 (0.36)	5.13 (0.42)	−0.10 (0.34)	0.62	0.29	0.82	0.24	0.66
Test 4	12 m rotation (right)	6.33 (0.56)	6.33 (0.49)	0.00 (0.23)	0.91	0.80	0.96	0.16	0.45
Test 5	12 m rotation (left)	6.33 (0.54)	6.40 (0.56)	−0.08 (0.31)	0.84	0.66	0.93	0.22	0.61
Test 6	180° turn on the spot (right)	0.93 (0.16)	0.90 (0.13)	0.03 (0.14)	0.55	0.20	0.78	0.10	0.26
Test 7	3-3-6 m sprint	7.11 (0.61)	6.98 (0.62)	0.14 (0.38)	0.80	0.58	0.91	0.28	0.75
Test 8	3-3-6 m rotation (left)	8.05 (0.74)	7.92 (0.81)	0.13 (0.36)	0.88	0.74	0.95	0.26	0.70
Test 9	3-3-6 m rotation (right)	8.06 (0.88)	7.82 (0.72)	0.24 (0.48)	0.79	0.53	0.91	0.37	0.94
Test 10	90°–90° turn on the spot with stop (left)	1.49 (0.26)	1.40 (0.18)	0.09 (0.19)	0.62	0.28	0.82	0.14	0.37
Test 11	12 m dribble	6.23 (0.68)	6.19 (0.60)	0.04 (0.45)	0.76	0.51	0.89	0.31	0.88
Test 12	12 m rotation dribble (right)	8.29 (1.31)	8.34 (1.20)	−0.05 (0.81)	0.80	0.59	0.91	0.56	1.58
Test 13	12 m rotation dribble (left)	8.30 (1.06)	8.24 (1.04)	0.06 (0.74)	0.76	0.52	0.89	0.51	1.44
Test 14	90°–90° turn on the spot with stop (right)	1.40 (0.20)	1.36 (0.16)	0.04 (0.16)	0.62	0.30	0.82	0.11	0.31
Test 15	Combination	14.44 (1.30)	14.41 (1.13)	0.04 (0.49)	0.92	0.83	0.97	0.34	0.96
Overall performance time (sum activities 2–15)		82.88 (7.22)	82.31 (6.41)	0.57 (2.14)	0.95	0.89	0.98	0.98	4.20

excellent (ICC = 0.95). The LoA95 show that an improvement of 4.20 s (5.1%) can be detected as a real improvement on the WMP test. The Bland–Altman plot for test–retest agreement of the overall performance time is shown in Figure 1. The mean difference between the WMP test and retest for the overall performance time was 0.57 s (±2.14). The variability of the differences between the two measurements seems to be constant over the range of the (mean) performance time scores. The ICC values for the individual activities ranged from 0.25 for the 180° turn on the spot (left) (no. 2) to 0.92 for the combination (no. 15). The four activities that measured turn on the spot (no. 2, 6, 10 and 14) show a low reliability (ICC ≤0.62), while the LoA95 for these activities were high (at least 0.3 s, 22.0%).

Discussion

This study describes the development of a new field-based WMP test to assess the capacity of mobility performance and its construct validity and test–retest reliability. To examine the construct validity, we hypothesised that classification, playing standard and sex will influence the performance on the test. The construct validity tests showed that the WMP test distinguishes sex and playing standards, but did not show differences between low and high classifications on the overall performance time. The test–retest reliability for the overall performance time was excellent, and an improvement of 4.2 s (5.1%) can be detected relative to the overall performance time. However, the reliability for the activities related with rotation on the spot and the 12 m sprint is low.

Test development

The WMP test which is introduced in this article is a simulation of mobility performance during matches specific to wheelchair basketball. The WMP test can easily be used by trainers, coaches and scientists to gain insight into the capacity of mobility performance of players. The developed WMP test meets the requirements which have been reported in previous studies of wheelchair court sports (Goosey-Tolfrey & Leicht, 2013; Mason, van der Woude, & Goosey-Tolfrey, 2013; Vanlandewijck, Theisen, & Daly, 2001). The WMP test is based on the most common aspects of mobility performance, the players are

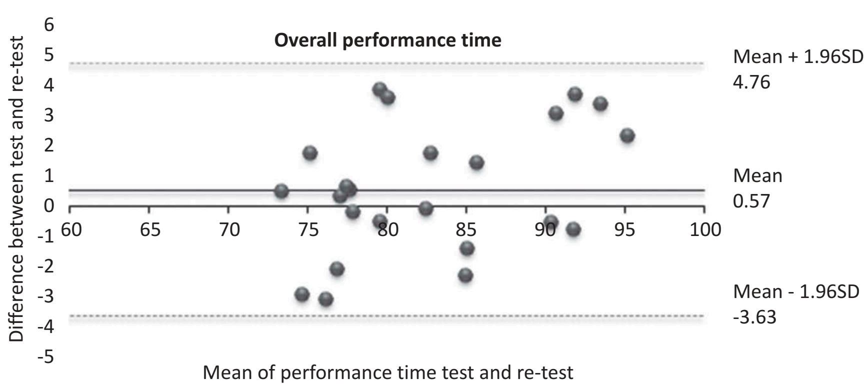

Figure 1. Bland–Altman graph for overall performance time on the wheelchair mobility performance test (n = 23). The solid line represents the mean difference between the test and retest. The dashed lines represent the 95% limits of agreement for the performance times (mean difference ± 1.96SD).

tested in their natural environment and they are tested with their own wheelchair configuration. However, mobility performance may change when essential aspects of the sport change, e.g., changes in the basketball rulings or wheelchair regulations. In the case of such changes, the mobility performance needs to be redefined.

Construct validity

Players with a high classification (≥3.0 points) are expected to perform better than players with a low classification (≤2.5 points) (Van der Slikke, Berger, Bregman, & Veeger, 2015; Vanlandewijck, Daly, & Theisen, 1999). The key determinants of the classification system are the ability to have active stability and rotation possibilities of the trunk (International Wheelchair Basketball Federation, 2014). Previous research shows that trunk impairment had impact on wheelchair propulsion, especially in accelerating from standstill (Chow et al., 2009; Vanlandewijck et al., 2001). The overall performance time of the WMP test showed a borderline non-significant difference ($P = 0.06$) and a moderate ES in capacity of mobility performance between low and high classifications. There were significant differences between classification levels on the separate activities related to driving forward movements (no. 3, 7 and 15). In contrast, almost all activities related to rotational movements of the wheelchair showed no significant differences, which could mean that classification (trunk impairment) has less influence on rotational movements. Furthermore, the used cutoff point for dichotomising classification in this study is debatable. Other studies showed differences between classification 1 (and 1.5) point players compared to the other classifications (Molik & Kosmol, 2001; Vanlandewijck et al., 2003; Vanlandewijck, Spaepen, & Lysens, 1995). Currently, there is not a clear relationship between classification and mobility performance. The impact and content of the classification system should be further investigated in future research.

The second hypothesis was that players competing at an international playing standard perform better than players at a national standard. This hypothesis proved to be true for the overall performance time and for 12 of the 14 separate activities with moderate-to-large ES (0.81–1.72). Except three activities related with turn on the spot, players at an international standard perform all the activities faster than national standard players. The difference between national and international playing standard on the overall performance time was 8.11 s, which is significantly more than the LoA calculated in the reliability study (4.20 s). Although the findings are in line with the hypothesis, the differences may be partly explained by other factors than the actual capacity of the athletes in mobility performance. Possibly, due to the more professional approach, international players may have a more optimised wheelchair configuration compared to national players which might have affected their performance on the test circuit. The activities, which showed no differences between playing standards, were again related with turn on the spot. These activities are, in addition to low reliability, not distinctive for playing standards. Turns on the spot are frequent elements of performance during matches and, therefore, important to include in the WMP test. However, time appears not to be a reliable outcome measure for these activities. In order to optimise the test, these activities must be further examined. At the moment, the WMP test is also analysed with data from inertial sensors using the method of Van Der Slikke, Berger, Bregman, Lagerberg, & Veeger (2015) with outcome measures such as velocity and acceleration.

The third hypothesis was that men perform better at the WMP test than women of the same playing standard. Except, again, for the activities related with turn on the spot, the hypothesis proved true. Men did perform all activities faster than women, except for the 12 m sprint with ball possession. The hypothesis is based on differences in upper body strength and trunk stability between men and women (Gomez et al., 2014). However, for the 12 m sprint with ball possession, ball-handling skills play an important role. For the rotational movement combined with ball possession, the hypothesis was proven. It may be possible that there is a difference in training focus between the international men and women in ball handling. Women may have better ball skills and with this they compensate for their slower performance on the 12 m sprint.

In this study, three hypotheses were formulated and tested to determine the construct validity of the WMP test. These hypotheses are chosen based on literature and practical feasibility. Several other variables than classification, gender and sex could have an influence on the mobility performance. Examples of variables which may also could have been used are floor surface and wheelchair configurations aspects such as wheel size, camber and elbow angle. Floor surface can affect performance due to a different rolling resistance, and the WMP test should reveal this difference. However, for the present study, it was practically difficult to organise to have players perform the test circuit at different floor surface. In addition, it should be mentioned that other variables than mentioned in the hypothesis might have partly affected the differences in mobility performance. In this study, we focused primarily on the construct validity of the WMP test and not at variables that best predict performance on the WMP test.

Reliability

The ICC values of the separate activities of the WMP test ranged between 0.25 and 0.95, and five of the 15 outcome measures showed low reliability (<0.70). The ICC of four activities that included a turn on the spot ranged between 0.25 and 0.62. The performance time of these activities is very short compared to the other activities. For example, the average duration for a turn of the spot (left) is 0.90 s with SEM of 0.1 s. The reason for these lower ICC values could be that the measurement error of these activities is relatively high due to the short performance times. Because of this, performance time may not be an adequate outcome parameter in these four activities. In this study, the reliability between the WMP test and retest on the 12 m sprint time was also low (ICC = 0.62). Previous research showed that time over a 15 m sprint cannot be used to assess wheelchair-specific capacity (Van der Scheer, de Groot, Vegter, Veeger, & van der Woude, 2014). In contrast, de Groot et al. (2012) reported a good reliability score (ICC 0.80–0.84) for a 5-m sprint test. These differences in reliability could be explained by the differences in handling the timing of deceleration to stop. In our study, the players had to stand still at the end of the 12 m, while in the study of de Groot et al. (2012), the players were allowed to drive over. The potential large variation between and within participants in timing of starting to decelerate and the level of braking (hand) forces needed to stand still at 12 m may have resulted in a relatively large variation of performance time and thus a low reliability score. The ICC of the 12 m sprint with stops is 0.80 and well in line with the study of de Groot et al. (2012). The 12 m sprint with stops is in this case divided in three short sprints of 3, 3 and 6 m and thus comparable in distance with the (single) 5 m in the study of de Groot et al. (2012). Although the total distance of the sprints with and without stops is the same, the inclusion of starts from stand still and stops seems to affect reliability. However, the design of the 12 m sprint as part of the WMP test, including the acceleration and deceleration phases, is in our opinion an essential element of mobility performance, also considering the results of the observations of wheelchair basketball matches (de Witte et al., 2016).

Limitations

All athletes performed the test in their own sports wheelchairs. Each wheelchair is individually adjusted in order to achieve an optimal wheelchair–athlete interaction. Although wheelchair configuration affects mobility performance, we do not expect this have biased our conclusions regarding validity and reliability of the WMP test because of the relatively large within-groups variability in wheelchair configurations. In addition, the choice to measure wheelchair basketball players in their own environment and wheelchair enhanced the external validity of the study. Another limitation of this study is the missing data of activity 1 (tik-tak box) for which, in future research, the video set-up must be examined.

Conclusion and practical implications

It can be concluded that the construct validity and reliability of the WMP test were good for the overall performance time score. The test can be used as a standardised mobility performance test to assess the capacity of mobility performance of elite wheelchair athletes in wheelchair basketball. In addition, novice players might use the test to achieve a higher level of mobility performance and monitor their progression in mobility performance aspects related to elite wheelchair basketball. The overall outcome of the WMP test is reliable. However, the activities related with turn on the spot (no. 2, 6, 10 and 14) show low reliability and construct validity.

The WMP test can be easily used to periodically monitor the capacity of wheelchair basketball players in mobility performance. The test results can be used to detect strengths and weaknesses of players in different aspects of mobility performance. For example, when a player performs driving forward actions significantly better than rotation actions – compared with team mates – the trainer can use these outcomes to develop specific training schemes. In addition, the test can be used to monitor the progress in mobility performance, to detect talented athletes and to examine whether an athlete is sufficiently recovered from an injury. For research purposes, we aim to use this WMP test to examine the impact of different wheelchair configurations on mobility performance, as recommended by Mason et al. (2013).

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